Instruction Manual

for

AN6520

DIGI-CAL™ II

Portable Digital
THERMOCOUPLE INSTRUMENT CALIBRATOR

ANALOGIC®

MP MASTER

MA29923

TRADEMARK INFORMATION: DIGI-CAL is a registered trademark of Analogic Corporation used to identify its line of thermocouple instrument calibrators.

ANALOGIC CORPORATION
Audubon Road • Wakefield, Massachusetts 01880
• Telephone (617) 246-0300 • Telex 94-9307 USA

NOTE: Made under one or more of the following U.S. patents:
3051939 3316547 3718923 3750146 3866307

Instruction Manual

for

AN6520

DIGI-CAL™ II

Portable Digital
THERMOCOUPLE INSTRUMENT CALIBRATOR

PROPRIETARY NOTICE

The information contained in this publication is derived in part from proprietary and patent data of the Analogic Corporation. This information has been prepared for the express purpose of assisting operating and maintenance personnel in the efficient use of the instrument described herein. Publication of this information does not convey any rights to use or reproduce it or to use it for any purpose other than in connection with the installation, operation, and maintenance of the equipment described herein.

First Edition

August, 1980
Printed in U.S.A.

CONTENTS

1. Introduction & Specifications
2. Preoperational Checkout
3. Operation & Applications
4. Service & Repair
5. Reference Data
6. Ordering Guide

Frontispiece. DIGI-CAL II Thermocouple Instrument Calibrator

1
INTRODUCTION & SPECIFICATIONS

1.1 SCOPE

This publication contains operating and maintenance instructions, as well as a description of the principles of operation, of the **DIGI-CAL II** Portable Digital Thermocouple Instrument Calibrator. The information covers all models of the instrument, including the basic equipment and its available options and accessories.

The manual, in so far as practicable, is a complete User Guide, providing step-by-step instructions for operating the DIGI-CAL II in each of its designed functions and with each of the built-in thermocouple data conforming programs. The publication also includes instructions for the use of standard EMF tabular data so that calibration of thermocouple sensors not incorporated in the DIGI-CAL II design Ranges (such as the Type B thermocouple) can be performed by table lookup from its DIGI-CAL II -measured voltage output. Calibration of thermocouple types in common use, including the Type C very high temperature sensor, can be performed by simple, direct reading measurements made with the DIGI-CAL II instrument.

1.2 GENERAL DESCRIPTION

The DIGI-CAL II (Frontispiece) is a microprocessor-based, laboratory grade, field portable, digital **calibrator, thermometer,** and **voltmeter.** It is packaged in a rugged metal case, and it is especially designed for multifunction use in the harsh environments of the process and service industries.

The DIGI-CAL II operates in any of four front-panel selected functions:

(1) As a **thermometer** (**FUNCTION** = **MEASURE**), providing direct °F or °C readout of a connected thermocouple;

(2) As a **calibrator** (**FUNCTION = CALIBRATE**), providing precise voltage outputs equivalent to the tabular values expected from a selected thermocouple at a settable temperature, or a settable voltage up to ± 101mV;

(3) As a **voltmeter** (**FUNCTION = MEASURE, RANGE =mV**), providing 4½-digit readout of a ±100mV range input, with microvolt resolution and automatic polarity indicated in the display;

(4) As a **self-tester** (**FUNCTION = TEST**), providing an over-all system performance check, assuring a valid calibration. Appropriate microprocessor-generated error messages are displayed for malfunctions that may occur during other functional use.

The DIGI-CAL II is available as a four-range or eight-range model, and each may be supplied for either 110 or 220 Vrms recharging power sources. Each model is configured for the **mV RANGE** selection, thus providing the millivoltmeter and direct settable voltage functions. The 4-range model provides for three thermocouple ranges (**J, K, T**), while the 8-range model provides for seven thermocouple ranges (**J, K, T, E, R, S, C**), in addition to the **mV** range.

Measurements and calibration outputs for front-panel selected thermocouple types are automatically corrected for reference-junction offsets. Direct millivoltmeter measurements and settable direct-reading calibration voltage outputs are provided without reference junction compensation.

Front-panel displays are presented on large (8mm high) LEDs. The decimal point is positioned automatically, and the minus (—) polarity sign is displayed for any negative value; the plus (+) polarity sign is understood for any positive value. The digital display is actually 7 positions: five decade positions are available for the 4½-digit value; the decimal point is incorporated to the right within one of these positions; the polarity sign (when appropriate) is always positioned to the far left; the symbol **F, C,** or **E** is displayed at the far right, as annunciators for **Fahrenheit, Celsius**,or **EMF** (millivolts), respectively.

Error messages of **HIGH**, **LO**, **OPEN**, or **Error** are respectively displayed when the temperature is above full scale, the temperature is below full scale, an open thermocouple lead is detected (or less than minus 101.1mV), or when a voltage greater than 101.1 mV is applied to the input terminals.

1.3 MECHANICAL DESCRIPTION

The DIGI-CAL II is assembled in a rugged metal carrying case, as shown in Figure 1-1, whose bottom half forms the instrument case, and whose lid may be used as a tilt stand support arrangement for easy viewing. There are no rear panel connections, indicators, or controls. Dimensions are shown in the illustration. Weight is less than 9.5 lb (4.3 kg).

The instrument is battery-powered, and is supplied with a rechargeable NiCd battery pack and an integral battery charging circuit. The recharger line cord is attached to the instrument and is stored in the front-panel storage compartment.

The DIGI-CAL II many be ordered for either 110 or 220 Vac recharging source power.

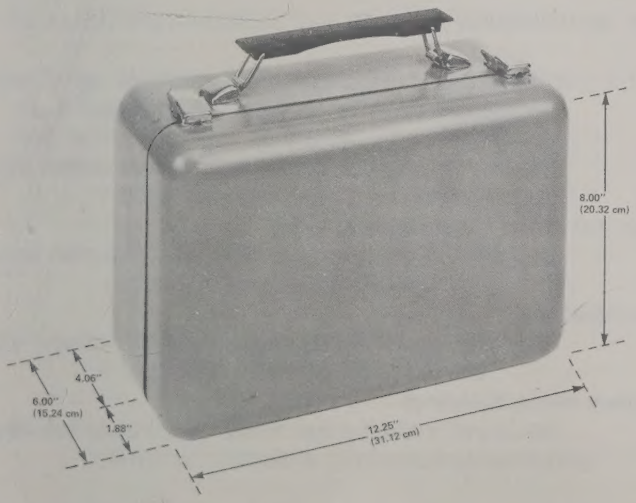

Fig. 1-1. Carrying Case and Dimensions

A fully charged battery pack will deliver typically 8 continuous operating hours, while 14 to 16 hours (when not in use) are required for full battery recharge. (The instrument may be operated while the batteries are being recharged.) The batteries are rated for a minimum of 1000 charge/discharge cycles. Replacement battery packs are easily installed, and may be ordered from the manufacturer.

The DIGI-CAL II front panel is made of a stain and impact-resistant thermoplastic, consistent with the instrument's intended use as a Calibrator/Thermometer in harsh field environments. The hinged lid is deep enough so that DIGI-CAL II accessories and documentation may be carried within the case without requiring additional storage space. A summary Operation instruction label is affixed to the inner lid surface, for ready field use and reference.

1.4 SPECIFICATIONS

1.4.1 UNIT TYPES

Four-Range: J,K,T, and mV
Eight-Range: J,K,T,E,R,S,C, and mV

1.4.2 MEASUREMENT FUNCTION

1.4.2.1 THERMOCOUPLE RANGES

Thermocouple (T/C) Types: Types J,K,T,E,R, and S per ANSI MC 96.1-1975. Type C per Hoskins Mfg. Co. See Reference Data Chapter for Standards Associations

Range, Resolution, Conformity & Accuracy

See Table 1

Input Impedance

1000MΩ or greater, during measurement interval

Maximum Source Resistance

5kΩ source or external lead resistance will cause less than 0.1°F (less than 0.05°C) error

Sensitivity
0.5, 1.429, 2.0, or 5.0 μV/count (range dependent)

Reference Junction Accuracy[1]
Automatically compensated. Maximum error
±0.017°/degree over 25°C ±10°C (60°F to 95°F) ambient

Range Tempco[2]
±15ppm/°C typ.; ±25ppm/°C max.

Zero Tempco
±0.00036mV/°C (±0.0002mV/°F) max.

Noise (±3σ)
< 1.5μV peak-peak

Open Thermocouple
Display reads "**OPEN**"

Input Overload
120Vdc or 120Vac rms, continuous without damage

1.4.2.2 MILLIVOLT RANGES

Input Range, Resolution & Accuracy
See Table 2

Input Impedance
1000MΩ or greater, during measurement interval

Range Tempco[2]
±15ppm/°C typ.; ±25ppm/°C max.

Zero Tempco
±0.00036mV/°C (±0.0002mV/°F) max.

Overload
120Vdc or 120Vac rms, continuous without damage

1.4.3 CALIBRATION (SOURCE) FUNCTION

T/C Output Ranges
Full range of selected T/C type (see Table 1)

mV Output Range
−12mV to +80mV

Setability
Infinitely variable temperature (°F/°C) setting for T/C ranges. Infinitely variable voltage (E) setting for mV range

Reference Junction Compensation
Same as for thermocouple measurement (provided for T/C ranges only)

Accuracy and Resolution
See Tables 1 and 2

Output Impedance
40Ω, max.

Overload(accidental input to DIGI-CAL II during Calibration)
3Vdc, 3Vac, or short to ground, continuous without damage

Max. Output Current (active pair of terminals accidentally shorted to each other)
Limited to 2.5mA

1.4.4 GENERAL SPECIFICATIONS

Warm-up Time
One minute for 1° T/C ranges and 0.01mV resolution range. Fifteen minutes for 0.1° T/C ranges and 0.001mV resolution range

Settling Time
0.5 second for rated accuracy

Normal Mode Rejection Ratio
50dB @ 50Hz or 60Hz

Common Mode Rejection Ratio
Not applicable for battery operation. 140dB when line powered (recharge mode)

Max. Common Mode Voltage
500V rms, in either battery or recharge mode

1.4.5 POWER

Type
Internal nickel-cadmium battery pack, rechargeable. Battery pack included

Continuous Operation

Eight hours typical

Recharge
14 to 16 hours for full battery charge. Unit can be operated continuously while on recharge (+5°C to +40°C). 18 - 20 hours recharge time required if operated while recharging.

Battery Life
1000 charge/discharge cycles min.

Continuous Recharge
Indefinitely without damage

Recharge Power
6.5 watts @ 110Vac or 220Vac ±20%, 47 to 400Hz. Unit includes grounded, three-wire line cord for specified power source. Externally accessible fuse

Operate Power
1.5 watts (Battery Mode)

1.4.6 CONTROLS & DISPLAY

Range Select

Rotary switch, four or eight ranges

Function Select

Rotary switch, four position: OFF, MEASURE, CALIBRATE, and TEST

°F/°C Select

Toggle switch, two position: °F or °C

Output Adjust (CALIBRATE functions only)

Dual concentric potentiometer, for coarse and fine adjustment of output (and of corresponding display)

Channel A/B Select

Toggle switch, two position

Display Type

Seven digit, seven segment planar, red LED display, 0.30'' (8mm) high

Display Readout Units

°F or °C for temperature, E for millivolts

1.4.7 DIAGNOSTIC DISPLAYS

Low Battery

Display blinks during a 10-minute warning period, then the unit powers down and the display turns off

Positive Temperature Overrange

''HIGH''

Negative Temperature Overrange
"LO"

Open Thermocouple Input
"OPEN"

Overrange mV Input
"ERROR"

Display Test
Display reads all "8's" when unit is turned on or range is changed

1.4.8 PACKAGE

Connectors
Two sets (channels A and B) of five-way binding posts (four posts total)

Housing
Metal case with handle; epoxy painted. Case color: rust. Panel color: gold

Weight and Size
9.5lb (4.3kg); 6"D x 8"W x 12.25"L (15cm x 20cm x 31cm)

1.4.9 ENVIRONMENTAL & RELIABILITY

Operating Temperature
−10°C to +40°C
(+14°F to +104°F)

Storage Temperature
−40°C to +60°C
(−40°F to +140°F)

Relative Humidity
0-90%, non-condensing

Moisture Seal
O-ring sealed waterproof case; splash-proof panel

Vibration
Each unit vibrated at 2g RMS for 30 seconds

Shock (drop test)
Meets the requirements of Mil-Std 202-E for safe transit

EMI/RFI
Shielding on six sides in standard metal case

Burn-in
100 hours typ with temperature cycles from 0°C to +55°C, (32° to 130°F), and power ON/OFF cycles. Battery pack is installed after burn-in, prior to final calibration

Calibration
NBS traceable

Certificate of Calibration
Detailed certificate of conformance shipped with each unit

MTBF
15,000 hours (5 years normal usage)

Warranty
Twelve months

Operator Safety
500V rms max. on input terminals

TABLE 1

Range, Resolution, Conformity, Accuracy & Stability of Thermocouple Measurement and Simulation Functions[1] (all values in degrees)

T/C Type (metals)	Scale	Temperature Range[2]	Resolution	Conformity[3]	RSS Calibration Accuracy[4]	Overall Accuracy, 1 year[5]
J	°F	−346 to +2192	0.1	±0.2	±0.29	±1
(Fe/CuNi)	°C	−210 to +1200	0.1	±0.1	±0.17	±0.6
K	°F	−328 to +2501	0.1	±0.2	±0.33	±1
(NiCr/NiAl)	°C	−200 to +1372	0.1	±0.1	±0.19	±0.6
T	°F	−337 to + 752	0.1	±0.2	±0.25	±1
(Cu/CuNi)		−405 to − 337	0.1	±9.2	±9.11	±10
	°C	−205 to + 400	0.1	±0.1	±0.15	±0.6
		−243 to − 205	0.1	±5.1	±5.10	±5.6
E	°F	−389 to +1832	0.1	±0.2	±0.27	±1
(NiCr/CuNi)		−422 to − 389	0.1	±5.0	±4.81	±5
	°C	−234 to +1000	0.1	±0.1	±0.16	±0.6
		−252 to − 234	0.1	±2.8	±2.71	±2.8
R	°F	− 58 to +3214	1	±0.2	±0.76	±2
(Pt13Rh/Pt)	°C	− 50 to +1768	1	±0.1	±0.65	±1.1
S	°F	− 58 to +3214	1	±0.2	±0.61	±2
(Pt10Rh/Pt)	°C	− 50 to +1768	1	±0.1	±0.54	±1.1
C[7]	°F	+ 32 to +2192	1	±0.2	±0.68	±1
(W5Re/W26Re)		+2192 to +3812	1	±0.2	±0.84	±2
		+3812 to +4200	1	±0.2	±0.97	±3
	°C	0 to +1200	1	±0.1	±0 56	±0.6
		+1200 to +2100	1	±0.1	±0.62	±1.1
		+2100 to +2315	1	±0.1	±0.69	±1.7

Notes To Specifications

1 Outside of this range (*i.e.*, from −10°C to +15°C ambient, and from +35°C to +40°C ambient), maximum reference junction error is ±0.035°/degree.

2 Range tempco applies from −10°C to +40°C ambient.

TABLE 2

Range, Resolution, and Accuracy of mV Measurement and Source Functions

Voltage Range[6]	Resolution	RSS Calibration Accuracy[4]	Overall Accuracy 1 year[5]
−20.000mV to +20.000mV	0.001mV	±(0.005% of reading +2 digits)	±(0.03% of reading +5 digits)
−101.10mV to −20.00mV; +20.00mV to +101.10mV	0.01mV	± (0.01% of reading +1 digit)	± (0.03% of reading of +2 digits)

Notes to Tables 1 and 2

1. For unlisted thermocouples, such as types B, W, Nisil, gold/chromel, etc., use the DIGI-CAL II millivolt range and appropriate mV vs. T tables (NBS Monographs, etc.). See paragraph 3.6.

2. For thermocouple calibrate functions, the output range is −12mV to +80mV, with resolution and accuracy per the corresponding temperatures shown.

3. Data conformity to ANSI Spec MC 96.1-1975.

4. Traceable to NBS.

5. Instrument at 25°C ±10°C.

6. For mV **MEASURE** operation, the instrument autoranges. For mV source operation (**CALIBRATE** function), the output range is −12mV to +80mV with resolution and accuracy per Table 2.

7. Per data supplied by Hoskins Mfg. Co., Detroit, MI U.S.A.

1.5 FUNCTIONAL DESCRIPTION

1.5.1 General

Under microprocessor control, the DIGICAL II "reads" the front-panel selected **FUNCTION** and **RANGE** switches and sets up the instrument to **MEASURE, CALIBRATE,** or **TEST** for the selected thermocouple (where appropriate). Figure 1-2 is a greatly simplified block diagram that illustrates the multifunction capabilities of this compact instrument. As shown in the illustration, the displayed value is derived from any one of several selectable inputs to the analog-to-digital (A/D) chain. The front-panel **FUNCTION** select switch determines whether the A/D input will be the signal connected to the front-panel terminals from some temperature sensor, or a voltage derived from one of three internal sources. The front-panel **RANGE** switch setting causes the microprocessor to calibrate the digitized signal in terms of the stored thermocouple tabular data and in °F or °C, as selected by a front-panel switch, or in units of millivolts when no thermocouple range has been selected.

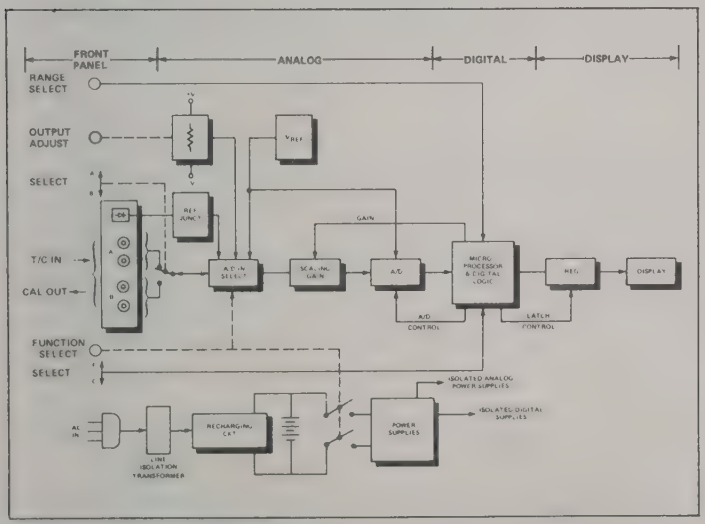

Fig. 1-2. System Block Diagram

In the measurement function, the signal connected to the input terminals is connected to the A/D chain. If a thermocouple range has also been selected, the signal from a reference junction sensor is also connected to the A/D chain.

In the calibration function, a settable voltage, whose value is similarly scaled, converted, and displayed is connected internally to the front-panel terminals. If a thermocouple range has also been selected, the output voltage is conformally mapped by the microprocesssor and compensated for the reference junction voltage.

In the self-test function, an internal precision reference voltage is similarly scaled and converted. (It is not connected to the terminals for external use, however.) As for the other functions, if a thermocouple range has also been selected, the converted value is conformally mapped for the particular thermocouple and compensated for the reference junction voltage value as well. Its digital value is displayed, and the reading may be compared with the value established at the factory final test and calibration. Because the test signal is processed through the complete chain as for any measure or calibrate function, the self-test exercises all of the components that are included in the normal operation.

Error messages are displayed if the performance does not meet preprogrammed requirements. If an open sensor lead (or open thermocouple or a voltage input more negative than minus (—) 101.1mV) is detected, the message **OPEN** is displayed. If the input value exceeds the preprogrammed full scale range for the selected thermocouple, the message **HIGH** or **LO** appears for the appropriate direction in which the signal exceeds the limits. If the input exceeds the maximum full scale range of 101.10 mV, the message **ERROR** is displayed.

1.5.2 The Two-Conversion Cycle

The digital display is updated twice a second for nine successive updates of the selected input signal to the A/D conversion chain. In the tenth 500-millisecond interval, only the output of the reference junction sensor is connected to the A/D chain. Its value is digitized and stored to be applied in the next nine display updates.

During each 500-millisecond period, the DiGICAL II performs two analog-to-digital conversions. In the first such conversion, lasting 200 milliseconds, the instrument makes a conversion with a minimum amplifier gain of 20. The microprocessor examines the result of that conversion and then sets the gain at 20, 50, 70, or 200 so that the next conversion will occur with a scaling for the greatest possible resolution of the displayed result. In effect, the DIGI-CAL II autoranges before every measurement or calibration, and updates its cold-junction reference compensation every 5 seconds.

1.6 APPLICATIONS

In Chapter 3 of this manual you will find detailed instructions for each of the following application areas:

(a) Measuring temperature with a thermocouple (T/C) in the DIGI-CAL II range.

(b) Measuring temperature with T/C's not in the DIGI-CAL II range.

(c) Calibrating thermocouple-type Recorders, Indicators, or Controllers.

(d) Checking Thermocouples.

(e) Checking mV-type Recorders, Indicators, or Controllers.

(f) Using the Digi-Cal II as a general-purpose millivolt digital voltmeter.

2
PREOPERATIONAL CHECKOUT

2.1 SCOPE

This chapter contains information on the installation, setup and pre-operation check of the DIGI-CAL II prior to its use as a Calibrator/Thermometer. The information includes instructions for unpacking and repacking the instrument, and for registering your warranty with the company. The chapter also includes information about the front panel operating controls and indicators and general information about the instrument's use. This information should be read carefully before attempting to use the DIGI-CAL II on site.

2.2 UNPACKING & REPACKING

a. Figure 2-1 identifies the components of the packaging configuration for DIGI-CAL II. As shown in that illustration, the instrument is placed in a waterproof plastic wrapper, securely fitted between molded-foam shock-isolators and placed with the documentation in its shipping carton. You will find the documentation inside the shipping carton. When unpacked, you should find:

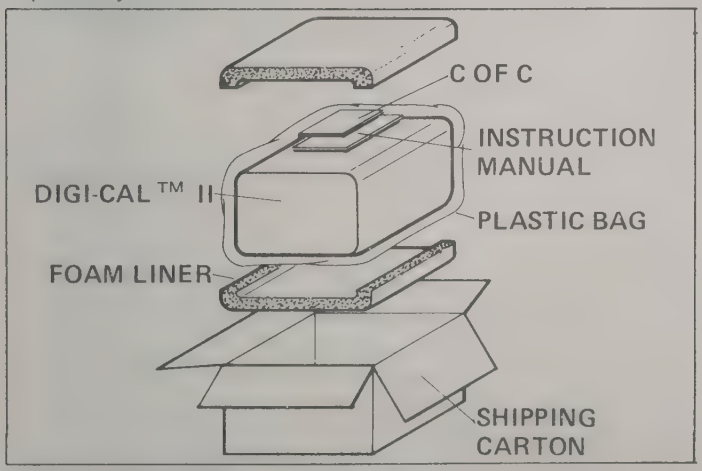

Fig. 2-1. DIGI-CAL II Shipping Configuration

(1) DIGI-CAL II (Thermocouple Instrument Calibrator)*
(2) Certificate of Calibration
(3) Warranty Card (In back of manual)
(4) Factory Test Data Sheet (Part of the Certificate of Calibration)
(5) Instruction Manual

*Battery pack and fuse are installed in the instrument. The recharger line cord is attached, and is located in the front-panel-accessed storage compartment.

b. Carefully examine these articles, noting especially the matching serial numbers of the instrument and the test data. Inspect the packing case and the instrument for any signs of damage during shipment and report immediately to the carrier. Fill out and return the warranty card which you will find inserted at the back of this manual in order to register your instrument and to establish your warranty service interval.

c. Accessories, such as a service cable, or adaptor plugs, may have been ordered with the instrument. These will be shipped in their own containers.

d. Retain the packing material for reshipment. When shipping DIGI-CAL II, use foam shock isolators and pack in original shipping carton, if available. If original shipping material is no longer available, use some shock isolators, such as bubble plastic, and wrap securely within a suitable carton.

2.3 DIGI-CAL II SETUP

The instrument is shipped in a complete configuration. The battery pack is installed, and it was shipped in a fully charged condition. To assure that the batteries will be operational after any prolonged shelf life, or after any extensive shipping interval, charge the batteries for a period of 15 hours. After an initial warmup period of 1 minute for 1°-resolution measurements (15 minutes for 0.1°-resolution measurements), the instrument is ready for operation. Refer to Chapter 3 for detailed operating instructions.

2.4 OPERATING CONTROLS & INDICATORS

Figure 2-2 illustrates the front-panel features, and includes a brief description of the operating controls and indicators.. Figure 2-3 is a schematic composite of a number of possible display formats, illustrating the location of decimal point, polarity sign, and annunciator codes. The illustration also indicates the location and appearance of possible error messages.

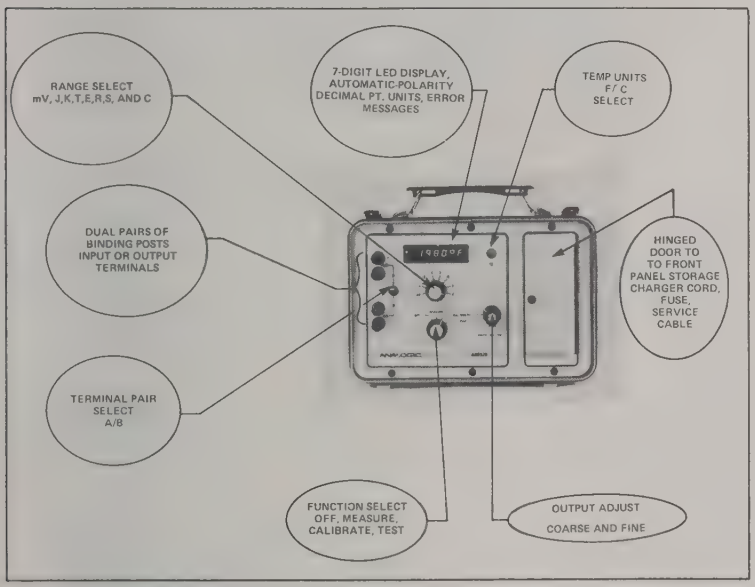
RANGE SELECT
mV, J,K,T,E,R,S, AND C
7-DIGIT LED DISPLAY, AUTOMATIC-POLARITY DECIMAL PT, UNITS, ERROR MESSAGES
TEMP UNITS F/C SELECT
DUAL PAIRS OF BINDING POSTS INPUT OR OUTPUT TERMINALS
HINGED DOOR TO TO FRONT PANEL STORAGE CHARGER CORD, FUSE, SERVICE CABLE
TERMINAL PAIR SELECT A/B
FUNCTION SELECT OFF, MEASURE, CALIBRATE, TEST
OUTPUT ADJUST COARSE AND FINE

Fig. 2-2. DIGI-CAL II Front Panel Features

250 1.0 °F -4 2 2.0 °F	Measures temperature directly from T/C types J, K, T, & E, with resolution of 0.1°F and 0.1°C.
23 15 °C - 50 °C	Measures temperature directly from T/C types R, S, & C with resolution of 1°F and 1°C
20.00 0E -20.00 0E	Measures ±20mV signals with resolution of 0.001mV (1μV)!
10 1.1 0E -10 1.1 0E	Measures ±20mV to ±101.1mV signals with resolution of 0.01mV
HIGH LO OPEN Error	Automatically indicates faults: temperature above or below the calibrated instrument range, or... open thermocouple, or... input signal greater than 101.1mV

Fig. 2-3. DIGI-CAL II Display Formats

2.5 INPUT TERMINALS / ACCESSORIES

The standard 5-way binding posts provide complete flexibility in making connections to the DIGI-CAL II. A terminal pair is spaced for simple "banana-jack" connection, as well as the spade-lug, single jack, or wire lead connection to the individual binding post. The availability of 2 pairs of the binding posts provide maximum flexibility for measurement and calibration.

The binding post connections are thermally coupled to an internal sensor to provide the input for the automatic Reference Junction Compensation (RJC) in the DIGI-CAL II. The reference junction temperature compensation is scaled for any one of the selected thermocouple ranges, and is therefore effective in the **Measure, Calibrate,** or **Test functions** when a thermocouple type is selected. The RJC is **NOT** included when the **mV** range is selected in any one of these functions.

To expedite the measurement and calbration operations, an optional thermocouple adaptor plug may be used for quick connect/disconnect of thermocouple units. The color-coded adaptor plugs are available in standard or miniature sizes and are pre-wired with short lengths of appropriate flexible thermocouple leads terminated at the other end in lugs. An optional **Instrument Service** cable is also available, providing a 6-ft length of flexible, paired thermocouple leads.

For economy, the accessory adaptor plugs and instrument service cables supplied for Types R and S are fabricated of copper vs. copper alloy #11, which is only useful at ambient temperatures.

2.6 PREOPERATIONAL TESTS

To obtain the maximum benefits when using your DIGI-CAL II, observe the following precautions and perform a simple self-test of the instrument.

(1) Set up for use in as draft-free an ambient as possible.

(2) Allow at least 1 minute for warmup before making measurements of 1°-resolution thermocouples or 0.01mV-resolution voltages. Allow 15 minutes for 0.1° T/C or 0.001mV resolution ranges.

(3) Operate on battery power, whenever possible.

Before each CALIBRATE/MEASUREMENT operation:

(1) Select the **TEST FUNCTION**.

(2) Rotate the **RANGE** selector through its eight range positions, starting with **mV**.

(3) For each **RANGE** position, the display value should be within the limits shown on the calibration label on the inside case cover.

Note that a "full" display appears momentarily after each range selection. Check the lighting of each of the 7 segments and decimal point that should appear in each of the 7 digits. Display reads ***8.8.8.8.8.8.8.*** (seven eights).

A blinking display indicates a low battery voltage. You have 10 minutes of continued in-spec DIGI-CAL II performance from the time the display starts blinking until the battery pack **MUST** be recharged. At the end of the 10-minute interval, the DIGI-CAL II is automatically programmed to stop its operation.

Start the recharge cycle as soon as possible after observing a low battery indication. DIGI-CAL II operation may be continued , if necessary, during the recharge operation.

If your DIGI-CAL II will not operate in the battery mode after several attempts at charging, it may be necessary to replace your battery pack. If within warranty (one year from date of purchase), contact your nearest distributor or factory service center.

3
OPERATION & APPLICATIONS

3.1 SCOPE

This chapter includes step-by-step instructions for using DIGI-CAL II in the **Measure, Calibrate,** and **Test** functions. You will learn how to use your DIGI-CAL II ...

•As a **Field Calibrator/Simulator**, to calibrate analog and digital thermocouple instruments, including panel meters, indicators/controllers, chart recorders, data loggers, thermocouple amplifiers, linearizers and bridges, X—Y plotters, millivoltmeters, VCO's, etc.

•As a **Measurometer** of wide temperature ranges from seven (7) basic thermocouple types incorporated in the memory of DIGI-CAL II.

•As a **millivolt generator** for calibrating other than thermocouple instruments.

•As a **precision millivoltmeter**, for precision measurements of low level signals from a variety of transducers and signal sources.

•As a **precision comparator,** to compare two thermocouples or other signal sources.

•As a **calibrator of thermocouples**, when used with a precision controlled temperature bath, such as "hi-temp" sand bath, 32°F ice bath, temperature-controlled oil bath, cryostat, and freeze-point standard.

•As a **digital thermometer**, to measure ambient temperature and special reference junction temperatures when used with a calibrated thermocouple.

•As a **laboratory instrument**, performing all the functions noted above, and especially useful where long-term precision temperature measurements and overnight calbrations with 0.1°-resolution and conformity are required.

•As a **self-testing and diagnostic tool**, indicating open thermocouples, or thermocouple signals above or below the range of specified thermocouples.

These applications are illustrated in the figures that follow, showing actual site hookups, including the use of accessory leads, adaptors, and external equipments.

In the lid of each DIGI-CAL II is a decal (4 or 8 range) giving abbreviated operating instructions in each of the three modes of DIGI-CAL II operation: **Measure, Calibrate, Test.** These decals also contain a listing of the various thermocouple types, their operating range in °F or °C, and the factory recorded test readings at 25°C ±10°C for each of the input ranges (mV as well as thermocouples). Read this Instruction Manual once, and thereafter you can rely on having operating instructions with you in the field at all times.

3.2 THERMOCOUPLE WIRES

In making measurements where additional wire must be connected to the thermocouple leads, care must be exercised in selecting these wire types, not only when they are claimed to be of the same composition as the thermocouple involved, but, also, of their ''quality''. Performance results where high precision is required and in circumstances where some type of thermocouple wire leads are added to the original installation should be reviewed carefully for the impact of the choice of the additional wire leads.

The quality of thermocouple wire is established by the limits of error to be expected in its use. There are three recognizable levels of quality:

Special Grade,
Standard Grade, and
Extension Grade.

The error limits determining the grade quality differ from thermocouple type to thermocouple type, reflecting the degree of difficulty in maintaining the precise levels of purity of the metals used. The table below summarizes the error limits for Special and Standard grades, while Extension grade wire is characterized by limits of error exceeding those in the table. Errors up to ± 8°F may be experienced when using Extension grade thermocouple wire for J and K thermocouples.

Limits of Error for Thermocouples*

	Temperature Range		Limits of Error Standard		Special	
Type	°F	°C	°F	°C	°F	°C
B	1600 to 3100	871 to 1705	± ½%			
E	32 to 600	0 to 316	±3°F	±1.7	±2¼°F	±1.3
	600 to 1600	316 to 871	± ½%		±3/8%	
J	32 to 530	0 to 277	±4°F	±2.2	±2°F	±1 1
	530 to 1400	277 to 760	± ¾%		±3/8%	
K	32 to 530	0 to 277	±4°F	±2.2	±2°F	±1 1
	530 to 2300	277 to 1260	±3/4%		±3/8%	
R or S	32 to 1000	0 to 538	±2½°F	±1.4		
	1000 to 2700	538 to 1482	± ¼%			
T	-300 to -150	-184 to -101			±1%	
	-150 to -75	-101 to -59	±2%		±1%	
	-75 to 200	-59 to 93	±1½°F	±0.8	± ¾°F	±0.4
	200 to 700	93 to 371	± ¾%		±3/8%	

*Per ANSI Standard C96.1

3.3 AS A FIELD CALIBRATOR/SIMULATOR, CALIBRATING T/C-TYPE INDICATORS, RECORDERS, & CONTROLLERS

...When the T/C type is among the DIGI-CAL II ranges (7 basic types or 3 basic types),

See Figure 3-1.

(1) Disconnect the T/C leads from the ***Instrument to be Calibrated.***

(2) Use appropriate T/C type and quality grade leads to connect the instrument to a DIGI-CAL II terminal pair.

(3) Select the DIGI-CAL II **CALIBRATE** function.

(4) Select the appropriate DIGI-CAL II **RANGE**.

(5) Use DIGI-CAL II Coarse and Fine **OUTPUT ADJUST** controls for a 0° display value.

Select DIGI-CAL II temperature unit **°F/°C** as used in the Instrument Being Calibrated.

If the Instrument Being Calibrated does not include a zero value in its Full Scale Range, set up the minimum value that can be displayed (or indicated).

(6) Adjust the Instrument ZERO for 0° (or minimum value) Instrument display (or indication).

(7) Use DIGI-CAL II **OUTPUT ADJUST** controls for an Instrument Full Scale Range output value.

(8) Adjust the Instrument RANGE (GAIN or SPAN) control for equal Instrument display (or indication).

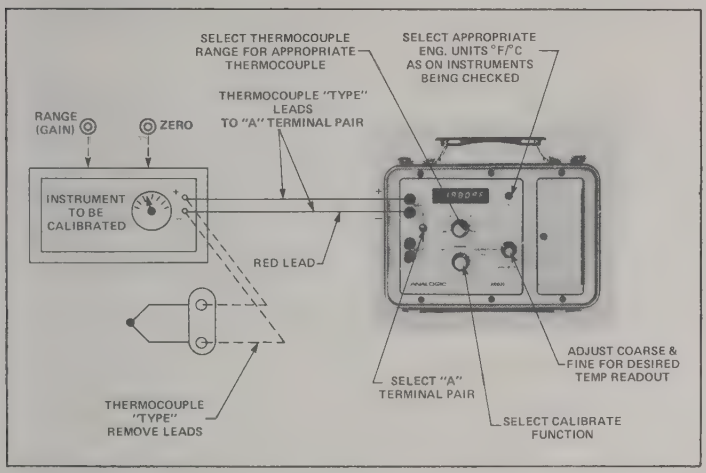
SELECT THERMOCOUPLE RANGE FOR APPROPRIATE THERMOCOUPLE
SELECT APPROPRIATE ENG. UNITS °F/°C AS ON INSTRUMENTS BEING CHECKED
THERMOCOUPLE "TYPE" LEADS TO "A" TERMINAL PAIR
RANGE (GAIN)
ZERO
INSTRUMENT TO BE CALIBRATED
RED LEAD
ADJUST COARSE & FINE FOR DESIRED TEMP READOUT
SELECT "A" TERMINAL PAIR
SELECT CALIBRATE FUNCTION
THERMOCOUPLE "TYPE" REMOVE LEADS

Fig. 3-1. Standard DIGI-CAL II Setup for Temperature Measurement

3.4 AS A MEASUROMETER™ OF TEMPERATURES WITH THERMOCOUPLES IN THE DIGI-CAL II RANGE

This procedure is applicable to circumstances where the thermocouple is of the type shown on the front panel RANGE selection (7 basic types or 3 basic types).

See Figure 3-2.

(1) Use **special or standard** thermocouple leads to connect to the thermocouple input terminals of DIGI-CAL II. You may use either pair of T/C terminals. Observe caution in connecting proper polarities. The red thermocouple lead is to be connected to the negative binding post terminal; connect the other lead to the positive terminal. Refer to the listing below for the color codes of the leads used with standard thermocouples.

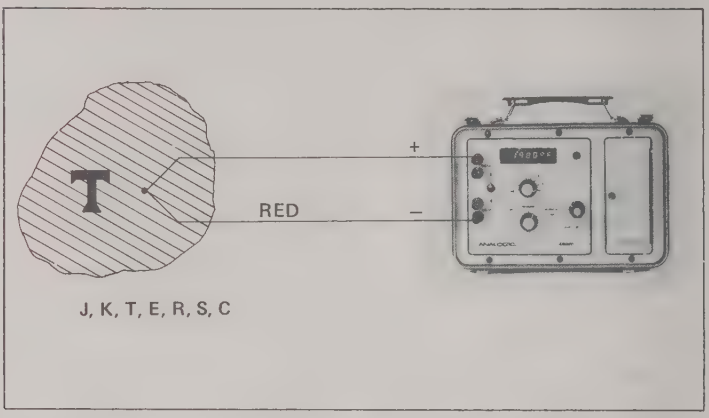

Fig. 3-2. Temperature Measurement with DIGI-CAL II T/C

THERMOCOUPLE LEAD COLOR CODES (ISA)

TYPE	PLUS(+)	MINUS(—)
T	Blue	Red
J	White	Red
E	Purple	Red
K	Yellow	Red
R, S	Black	Red
B	Green	Red

(2) Turn the A/B channel select switch to the connected terminal pair. (Figure 3-2 indicates connection to the "A" terminal as an example only.)

(3) Rotate the **RANGE** selector switch to the appropriate thermocouple type.

(4) Rotate the **FUNCTION** selector switch to the **MEASURE** function.

(5) Select the desired temperature units, **°C / °F**.

(6) Read the temperature in the display. The value has been compensated automatically for the reference junction temperature.

3.5 AS A MILLIVOLT GENERATOR FOR CALIBRATING VOLTAGE MEASURING/DISPLAY INDICATORS

When used in the **CALIBRATE FUNCTION** and **mV RANGE**, the DIGI-CAL II provides a precision millivolt range calibration signal that may be used as a standard input to calibrate such devices as X—Y Plotters, Strip Chart Recorders, Data Loggers, etc.

Replace the normal millivolt-level input to the instrument to be calibrated with the output of the DIGI-CAL II.

Adjust the DIGI-CAL II output with the Coarse and Fine controls for the desired value as indicated in the display.

Adjust the instrument GAIN for the proper indicated value.

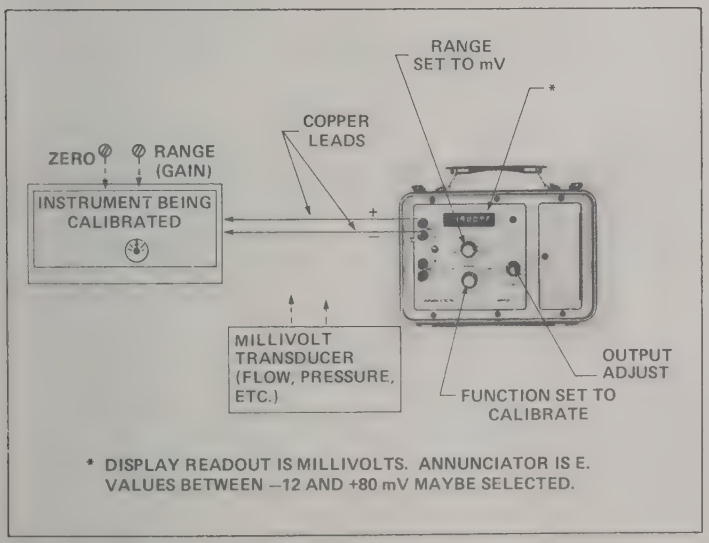

Fig. 3-3. Calibrating mV Measuring/Display Indicators

3.6 AS A PRECISION MILLIVOLTMETER, MEASURING THERMOCOUPLES NOT COVERED IN THE DIGI-CAL II RANGE OR OTHER TRANSDUCERS

The DIGI-CAL II is a convenient field portable device for measuring the outputs of transducers such as pressure gauges, flowmeters, level indicators, force indicators, etc., where such outputs are in the millivolt level.

Merely connect the output of such devices to the DIGI-CAL II, and operate the DIGI-CAL II in the **MEASURE FUNCTION** and **mV RANGE**. (The reference junction temperature compensation is removed from the measuring circuit in the mV RANGE.)

Consult available tables of Emf vs. Engineering Units to convert the millivolt readings to appropriate engineering units.

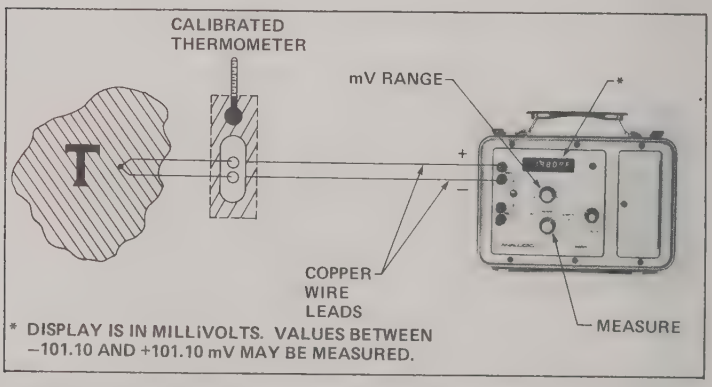

Fig. 3-4. Temperature Measurement via mV Function

Where temperature-vs-Emf tabular data is available, the DIGI-CAL II may be used to convert precision measurements of thermocouple outputs into values of temperature when the thermocouple is not one of those in the DIGI-CAL II memory.

See Figure 3-4.

(1) Connect the transducer reference terminals to DIGI-CAL II with copper leads. Observe the proper polarity conventions: being sure to connect the negative T/C terminal to the negative binding post terminal.

(2) Use a calibrated thermocouple (see paragraph 3.8 below) or thermometer to measure the temperature of the reference junction (where the copper leads are connected to the transducer leads). The other input binding posts of the DIGI-CAL II may be used with the calibrated T/C to obtain the reference junction temperature with minimum additional operations.

(3) Select the DIGI-CAL II **MEASURE** function.

(4) Select the DIGI-CAL II **mV** range.

(5) Read the millivolt value on the DIGI-CAL II display. Record.

(6) Use an approved tabular listing of transducer temperature vs. voltage and convert the values recorded in steps (2) and (6) above as shown in the sample below.

Assume the use of thermocouple Type B. Tables for this type are available in NBS Monograph 125.

Assume reference junction temperature is 65 °F in step (2). Look up the tables, and obtain the equivalent millivolt value for 65 °F:

65 °F → −0.003 mV

Assume a millivolt display value of 0.549 in step (5).

Since the reference junction temperature is above the table reference point of 32°F, add the two values algebraically:

−0.003 mV
+0.549 mV
+0.546 mV

.... the true 32°F (0°C) reference-junction compensated voltage.

Look up the tables to obtain the temperature for 0.546 mV:

It is between 635 and 636 °F.
The Temperature is 635.5 °F.

3.7 AS A PRECISION COMPARATOR, COMPARING TWO THERMOCOUPLES OR OTHER SIGNAL SOURCES

a. When both T/C elements are of the same type and one of the DIGI-CAL II Range types,:

(1) Connect each to a pair of binding-post terminals, using the same type and quality grade of thermocouple leads.

(2) Select the DIGI-CAL II **MEASURE** function.

(3) Select the DIGI-CAL II **RANGE** type for the T/C involved.

(4) Be sure the thermocouple probes are as close together as possible in the heat source. Tight contact of the two probes is a preferable condition, if obtainable.

(5) Alternately select input terminal pair **A** and **B.**

(6) Read and record the alternate displays. Remember that the DIGI-CAL II goes into a display test mode with each new selection, before the measured value appears.

b. When the T/C units are not among those in the DIGI-CAL II Range,:

See Figure 3-5.

(1) Connect the thermocouple leads to copper extension wires. These connections form the reference junction. Immerse the reference junction in an ice bath which is maintained at °C (32°F) by using crushed ice and water and stirring thoroughly.

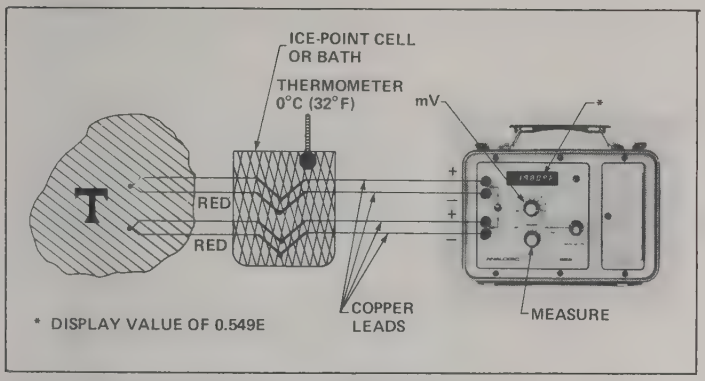

Fig. 3-5. Comparing Thermocouple Performance

(2) Connect the reference junction ice point to the DIGI-CAL II. Observe the proper polarities; red lead to negative terminal.

(3) Select DIGI-CAL II **MEASURE** function.

(4) Select DIGI-CAL II **mV** range.

(5) Select alternate DIGI-CAL II input terminals **A, B**.

(6) Read and record the alternate display values.

c. When different T/C types are to be compared:

.....(1) and both are among the DIGI-CAL II ranges,
follow procedure **a**. above, but select the appropriate T/C Range type corresponding to the T/C connected to the input when A/B selection is made.

.....(2) and at least one is not among the DIGI-CAL II ranges,
follow the procedure of **b**. above, but use the different electronic ice point adaptors for each T/C element. Compare mV display values.

3.8 AS A CALIBRATOR OF THERMOCOUPLES, USING PRECISION TEMPERATURE BATHS

The DIGI-CAL II is a laboratory grade instrument. Its accuracy as a precision measurometer and its display resolution make it suitable for laboratory calibration of thermocouples (whether or not they are within the DIGI-CAL II memory). To accomplish the procedure described in this paragraph, one or more of the Precision Temperature Baths shown in Figure 3-6 must be available..

(1) Immerse the thermocouple in the Precision Temperature Bath, whose temperature is known to an accuracy of ±0.01°C to ±0.1°C.

(2) Select the appropriate thermocouple type **RANGE**. Select the **MEASURE FUNCTION**. If the thermocouple is not among the DIGI-CAL II ranges, select the **mV RANGE**.

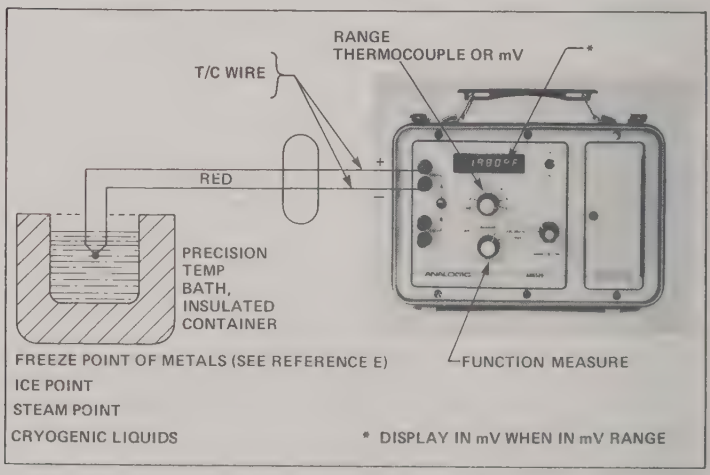

Fig. 3-6. Calibrating Thermocouples in Precision Temperature Baths

(3) Read the sensed temperature (or the millivolt value).

(4) Record the difference between the value of the Precision Temperature Bath and the measured value on the display.

(5) Calculate the instrumentation error as the root-sum-square of the possible error introduced by the DIGI-CAL II for the thermocouple type and temperature range (see specifications) plus the error introduced by the thermocouple wire (see paragraph 3.2) plus the inaccuracy of the Temperature Bath.

3.9 AS A PRECISION DIGITAL THERMOMETER USING CALIBRATED THERMOCOUPLES

The precision and accuracy of the DIGI-CAL II make it possible to perform temperature measurements with a **Special Grade** thermocouple with an accuracy hitherto unavailable for field instruments.
(The accuracy of the precision thermocouple may be checked by using the procedure of the previous paragraph.)

Use the DIGI-CAL II in the **MEASURE FUNCTION** and select the **RANGE** of the thermocouple in use.

Determine the possible error of the measurement by calculating the root-sum-square of the errors determined from the table of Limits of Error for the thermocouple used plus the error of the DIGI-CAL II as determined from the specifications.

3.10 AS A LABORATORY INSTRUMENT, WHERE HIGH PRECISION, LONG TERM TEMPERATURE MEASUREMENTS ARE REQUIRED

Refer to Figure 3-7.

The DIGI-CAL II is particularly well suited for laboratory use where very precise temperature measurements (±0.1°) are to be monitored unattended over long periods, such as overnight.

(1) Connect the temperature measuring device (chart recorder, indicator, controller, data logger, etc) to the DIGI-CAL II.

(2) Use the DIGI-CAL II in its recharging mode (the battery life is typically 6 to 8 hours when fully charged).

(3) Place the thermal measuring environment in a protected enclosure to insure the absence of draft-induced changes in ambient temperature.

(4) Pack the DIGI-CAL II input terminals in a foam rubber or plastic to maintain an insulated reference junction environment.

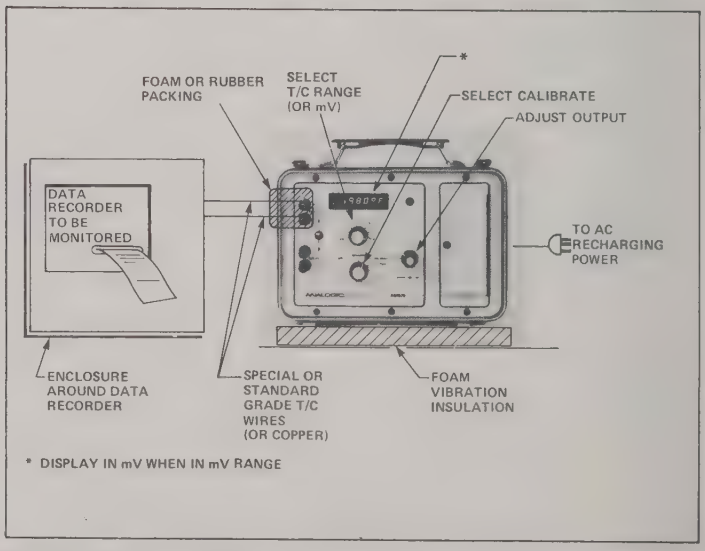
FOAM OR RUBBER PACKING
SELECT T/C RANGE (OR mV)
*
SELECT CALIBRATE
ADJUST OUTPUT
DATA RECORDER TO BE MONITORED
TO AC RECHARGING POWER
ENCLOSURE AROUND DATA RECORDER
SPECIAL OR STANDARD GRADE T/C WIRES (OR COPPER)
FOAM VIBRATION INSULATION
* DISPLAY IN mV WHEN IN mV RANGE

Fig. 3-7. Checking T/C Type Indicators, Recorders, & Controllers over Long Time Periods

(5) Set up the DIGI-CAL II for the appropriate RANGE and CALIBRATE FUNCTION.

(6) Adjust the DIGI-CAL II output for the desired reading. Operate the DIGI-CAL II as for normal procedures.

(7) Because of the precision and stability of DIGI-CAL II over long periods of time (such as overnight), you can now detect small temperature variations of 0.1° in process recording, monitoring, and controlling instruments.

3.11 AS A SELF-TESTING DIAGNOSTIC TOOL

The DIGI-CAL II may be used as a trouble-shooting tool in installations where malfunctioning thermocouples are suspected.

Merely connect the suspect thermocouple (or other millivolt transducer) to the DIGI-CAL II and set the front panel controls for the appropriate RANGE (T/C type or mV) and FUNCTION (MEASURE).

The DIGI-CAL II will display an appropriate error message if the transducer has an open lead or if the output exceeds the high or low levels of the specified component. See the table of such error messages in Figure 2-3.

3.12 STANDARD OPERATING INSTRUCTIONS

A decal has been placed in the lid of the carrying case for the DIGI-CAL II and is reproduced on the following page for reference purposes. The information contained in the decal provides standard operating instructions for the instrument, and serves as a ready reminder in all field applications.

3.13 SPECIAL APPLICATIONS

For the petrochemical and pipeline industries, where Intrinsic Safe operation is required, the DIGI-CAL II may be used with an approved barrier system without serious degradation of performance in either the Measurement or Calibration Mode.

AN6520 OPERATION

MEASUREMENT MODE

1. Connect the thermocouple leads or millivolt input leads to either the A or B set of input binding post terminals. Set the channel A/B input selector switch accordingly. Connect the red thermocouple lead to the minus (-) terminal for thermocouple temperature measurements. Use copper leads for millivolt measurements.
2. Set FUNCTION selector to MEASURE.
3. Set RANGE selector to mV or to the thermocouple type attached to the AN6520.
4. Select °F or °C for the temperature readout desired.
5. Readout displays measurement value. Readout displays °F or °C for temperature* and E for millivolts. Allow one minute warm-up for one degree resolution and a fifteen minute warm-up for tenth degree resolution.

NOTE

READ INSTRUCTION MANUAL FOR FURTHER OPERATIONAL DETAILS.
*Per ANSI Standards, IPTS-68, and NBS Monograph 125.

CALIBRATE MODE

1. Disconnect the signal or sensor leads from the input of the instrument to be calibrated
2. Connect the AN6520 to the input of the instrument to be calibrated using thermocouple wire of the same type as the calibration; use copper leads for millivolt calibration. See step 1 of MEASUREMENT MODE.
3. Set the FUNCTION selector to CALIBRATE.
4. Set the RANGE selector for the thermocouple type required for the thermocouple calibration, or to mV for millivolt calibrations.
5. Select °F or °C for thermocouple calibrations.
6. Adjust the COARSE AND FINE controls of the OUTPUT ADJUST potentiometer for the thermocouple calibration temperature* or millivolt calibration voltage desired as defined by the display.
7. Readout and warm-up per step 5 of MEASUREMENT MODE.

TEST MODE

1. Set FUNCTION selector to TEST.
2. Set °F or °C selector to °C.
3. Readout will be per the TEST READING of the below table (input leads need not be disconnected).

DIAGNOSTICS

1. Display reads OPEN for: an open input; sensor burnout; or millivolt readings below minus 101.1 mV.
2. Display reads HI or LO for temperatures outside the measurement range (see Chart).
3. Display reads ERROR for millivolt inputs greater than +101.1 mV.
4. A flashing display indicates a low battery condition.

OPERATING RANGE					
RANGE*	ANSI ALLOY	ANSI COLOR	°F	°C	RESOLUTION
mV	Copper/Copper	———	±101.1 mV		001/ 01**
J	Iron/Constantan	White/Red	-346 to 2192	-210 to 1200	0.1
K	Chromel/Alumel	Yellow/Red	-328 to 2501	-200 to 1372	0.1
T	Copper/Constantan	Blue/Red	-405 to 752	-243 to 400	0.1
E	Chromel/Constantan	Purple/Red	-422 to 1832	-252 to 1000	0.1
R	Pt/Pt 13% Rhodium	Black/Red	-58 to 3214	-50 to 1768	1.0
S	Pt/Pt 10% Rhodium	Black/Red	-58 to 3214	-50 to 1768	1.0
C	W5Re/W26Re	———	+32 to 4200	0 to 2315	1.0

**0.001 mV from -20 mV to +20 mV

TEST READINGS AT 25±10°C	
mV	±0.012 mV
J	±0.3°C
K	±0.4°C
T	±0.4°C
E	±0.3°C
R	±2°C
S	±2°C
C	±2°C

ANALOGIC®

DIGI-CAL™ II

MODEL

AN6520-8A-

S/N

4
SERVICE & REPAIR

4.1 SCOPE

This chapter describes rudimentary field maintenance for DIGI-CAL II. Such maintenance is limited to replacement of fuses, battery packs, and some mechanical components.

A separate Service Bulletin is available, however, providing complete schematics, assembly drawings, and parts lists. It may be ordered from the factory for a nominal charge. Refer to the request card attached with the warranty card at the back of this manual.

CAUTION

The DIGI-CAL II is covered by a factory warranty, and it should be returned to the factory for any repairs required within the warranty period. Attempts to effect repairs during the warranty period may void the warranty. Only qualified service personnel should attempt to make such repairs.

4.2 PREVENTIVE MAINTENANCE

The DIGI-CAL II should be inspected regularly for the appearance of dirt, loose terminals, knobs, and switches. A thorough inspection, cleaning, and mechanical checking should be performed as soon as possible after any period of operation in particularly severe dusty or corrosive areas. Keep the instrument covered when not in use to minimize the effects of the field environment.

4.3 CORRECTIVE MAINTENANCE AND REPAIR

Apparent malfunctions should be confirmed by performing the TEST FUNCTION and comparing results with the performance data in the calibration label in the DIGI-CAL II case lid. When this test indicates a proper functioning DIGI-CAL II, and there is still evidence of improper results, check external connections very carefully. Be sure that all external effects, such as draft-induced ambient temperature fluctuations, crossed-terminal polarity connections, and incorrect lead materials are identified and checked before assuming an equipment malfunction.

Repair of the DIGI-CAL II is limited to pc-board replacement, and should be accomplished by your distributor or Certified Factory Service Center. All such certified repairs will include a complete recalibration.

Organizations that maintain a Qualified Metrology Service Center should obtain the comprehensive Service Bulletin by using the attached request card.

4.4 RECALIBRATION

Recalibration of your DIGI-CAL II should not be required for one year. Refer to the Service Bulletin for Recalibration procedures when required.

4.5 BATTERY PACK REPLACEMENT

When your DIGI-CAL II unit will no longer operate in the battery mode, replace the battery pack, following the procedure described in the Service Bulletin.

5

REFERENCE DATA

A. Temperature Measurement Definitions
B. Standards Organizations
C. Hi-Temp Thermocouples
D. Reference Publications
E. Temperature Standards

Reference Data A

DEFINITIONS

CRYOGENIC

Very low temperatures; used in reference to liquified gases such as LOX (−297°F) and LN2 (−320°F). Requires use of high resistance Platinum RTD's (500-5,000 ohms), gold-chromel thermocouples or low temperature thermistors.

DIN STD.

A European Temperature Standard. DIN STD. 43710 establishes thermocouple curves.

DUPLEX SENSOR

A dual thermocouple usually isolated from each other and in the same housing or sheath.

FREEZE POINT STD.

Provides known fixed feference temperatures, the freezing points of metals. They are usually not monitored by a reference thermometer since the pure metal samples are certified. Typical examples:

METAL	FREEZING POINTS	
	°C	°F
Tin	231.97	449.55
Zinc	419.58	787.24
Aluminum	660.37	1220.67

KAPTON

A Dupont Company Polyimide insulation material; Radiation Resistant, Maximum Temperature 285°C. Used for high temperature lead wire insulation for RTDs and T/C.

MINERAL INSULATED

A term used to express a swaged or drawn thermocouple construction where a minieral oxide insulation usually magnesium oxide or aluminum oxide is densely compacted in a sheath for rugged bendable high temperature, sensor construction.

O.D. (Tubing vs. Pipe)

Outside diameter, the proper way to size thermocouple sheath tubing vs. inside diameter used for pipe sizing.

PLATINEL

A special high output/high temperature platinum alloy thermocouple (Trademark of Englehard Industries). Has an EMF output of 0-51 mv. over span of 32°F to 2372°F. Composition is gold, platinum and palladium. Usual diameter is .020'' per lead.

REFERENCE JUNCTION

The other junction (usually at ice point) to which the measuring thermocouple junction is compared. The output voltage of a T/C is approximately proportional to the temperature difference between the measuring (hot) junction and the reference (cold) junction.

RESPONSE TIME

(Time constant of a sensor). The time necessary for the sensor to reach 63.2% of step change in temperature with the sensor in water at a velocity of three (3) Ft/Sec, transverse to the sheath.

TEFLON/TEFZEL

Medium temperature wire insulations useful to 500°F and 390°F, respectively. Tefzel has some radiation resistance.

THERMOCOUPLE

Two dissimilar metals with a voltage output proportional to temperature. ANSI types:

		Temperature(max)
J	Iron — Constantan (copper — nickel)	2192°F*
K	Chromel — Alumel (NiCr vs. NI-Al.)	2501°F
T	Copper — Constantan (Copper — Nickel)	752°F
E	Chromel — Constantan (NiCr . vs. Cu-Ni)	1832°F
R	Platinum — vs. Plat. 13% Rhodium	3214°F
S	Platinum vs. Platinum 10% Rhodium	3214°F
B	Plat. 6% Rhodium vs. Plat. 30% Rhodium	3308°F
(Non-ANSI): C	W 5% Rhenium vs. W 26% Rhenium	5000°F

*When used for ANSI extended range.

THERMOWELL

The pressure vessel into which a thermocouple is inserted for easy removal and/or replacement purposes.

TEMPERATURE DEFINITIONS SUPPLEMENT

OFHC

Oxygen free high conductivity copper, one leg in type T thermocouples, the other leg being an alloy of approximately 60/40 copper nickel.

ALLOY 11

An alloy of copper with addition of approximately 0.5% nickel. Used with pure copper as compensating lead wire for platinum/Platinum-Rhodium thermocouples types R & S.

NICROSIL/NISIL

Thermocouple improvements on type K to eliminate the instability caused by high-temperature drift and short-term changes in emf in the 250-550°C range. Data available in NBS Monograph 161. Composition is:

	Nicrosil	Nisil
Chromium	14.2%	
Silicon	1.4%	4.4%
Nickel	Balance	Balance

Nicrosil/Nisil are useful from 0°C to 1300°C (2372°F), where the emf output is about 47.5mV.

LIMITS OF ERROR

The deviation in degrees or % of Standard or Special grade (see table below for definition of **standard, special**) thermocouples in emf outputs from an ideal calibration. This tolerance or calibration normally applies only from 0°C up to the maximum temperature for each thermocouple. Sub-zero limits require special calibrations.

JUNCTION—FORMING

The means of forming the electrical contact between the two wires of a thermocouple. Methods include:

Type E — Soft or silver soldering for low temperature operation.

Type J, K, T — Gas Welding; the wires are twisted together through two or three turns, held vertically in a vise and joined by fusion with a gas flame (using only borax as a flux).

Limits of Error for Thermocouples*

	Temperature Range		Limits of Error Standard		Special	
Type	°F	°C	°F	°C	°F	°C
B	1600 to 3100	871 to 1705	±½%			
E	32 to 600	0 to 316	±3°F	±1.7	±2¼°F	±1.3
	600 to 1600	316 to 871	±½%		±3/8%	
J	32 to 530	0 to 277	±4°F	±2.2	±2°F	±1.1
	530 to 1400	277 to 760	±¾%		±3/8%	
K	32 to 530	0 to 277	±4°F	±2.2	±2°F	±1.1
	530 to 2300	277 to 1260	±3/4%		±3/8%	
R or S	32 to 1000	0 to 538	±2½°F	±1.4		
	1000 to 2700	538 to 1482	±¼%			
T	-300 to -150	-184 to -101			±1%	
	-150 to -75	-101 to -59	±2%		±1%	
	-75 to 200	-59 to 93	±1½°F	±0.8	±¾°F	±0.4
	200 to 700	93 to 371	±¾%		±3/8%	

*Per ANSI Standard C96 1

Arc Welding. for small or medium diameter wires. Requires no flux. The arc is struck between the twisted tip and a piece of carbon rod.

Resistance Welding. For all thermocouples of very small diameter wires. Uses a capacity discharge type welder. Useful for R,S,B,C,W,J,E,T, & K.

Reference Data B.

STANDARDS ORGANIZATIONS

ANSI	American National Standards Institute
ASTM	American Society for Testing & Materials
BS	British Standards (Nat'l. Physical Laboratory — U.K.)
CSA	Canadian Standards Association
DIN	Deutsches Institut fur Normung (Germany)
IEC	International Electrotechnical Commission
IPTS	International Practical Temperature Scale
JIS	Japanese Industry Standards
NBS	National Bureau of Standards (United States)

Reference Data C.

HI-TEMP THERMOCOUPLES (OVER 2000°F)

T/C	MAXIMUM TEMPERATURE °F	°C	COMPOSITION
R	3214°F	1768°C	Pt13Rh/Pt
S	3214°F	1768°C	Pt10Rh/Pt
B	3308°F	1820°C	Pt6Rh/Pt30Rh
W	4200°F	2315°C	W/W-26Re
C	5000°F	2760°C	W5Re/W-26Re
W-Re(Englehard)	4352-5072°F	2400-2800°C	W3Re/W-25Re
Platinel**	2372°F	1300°C	Gold-Plat.-Palladium
Nicrosil/Nisil (N)	2372°F	1300°C	Nicrosil/14.2%Cr 1.4%Si/Bal Ni Nisil/4.4%Si/Bal Ni
K	2501°F	1372°C	NiCr/NiAl
PlMo	2900°F	1600°C	Platinum-Molybdenum
PL20Rh/PL40Rh	3272-3362°F	1800-1850°C	Platinum-Rhodium
Iridium vs.*_____ Iridium-Rhodium	3632°F	2000°C	Iridium-Rhodium

*40,50 or 60%

** Platinel is a registered trademark of Englehard Industries.

Reference D.

Reference Publications

NBS Monograph 125: Thermocouple reference tables based on IPTS-68. Covers standard thermocouple types J, E, T, K, R, S, B. Emf vs. T tables in both Fahrenheit and Celsius degrees.

NBS Monograph 161: Thermocouple reference tables for Nicrosil/Nisil, high temperature thermocouples.

Monographs 125 and 161 are available from Superintendent of Documents, US Government Printing Office, Washington, D.C. 20402 USA. Monograph 125 is SD Catalog No. CD13.44:125.

ANSI publication MC96.1-1975, covers thermocouples J, K, T, E, R, S, B.

Available from American Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018 USA.

ASTM publication E230-72, covers thermocouples J, K, T, E, R, S, B.

ASTM publication 470A, Manual on the Use of Thermocouples in Temperature Measurements.

ASTM publication STP-492, The Theory and Properties of Thermocouple Elements.

ASTM document E696, on Tungsten-Rhenium thermocouples.

ASTM publications are available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103, USA.

ISA Publications:

R.P.1.1 Coding of Thermocouple Wire
R.P.1.2 Thermocouple & Extension Wire
R.P.1.4 Thermocouple Fabrications
R.P.1.6 Temperature Emf Tables for Thermocouples

ISA publications are available from Instrument Society of America, 67 Alexander Drive, P.O. Box 12277, Research Triangle Park, North Carolina 27709, USA.

Reference E

Temperature Standards

	°F	°C
Freeze Points of Metals		
Tin	449.55	231.97
Lead	621.36	327.42
Zinc	787.24	419.58
Antimony	1167.33	630.74
Aluminum	1220.67	660.37
Silver	1763.47	961.93
Gold	1947.97	1064.43
Copper	1981.76	1083.20
Cryogenic (sub-zero)		
CO_2(Dry Ice) + Acetone	-110	-78.9
Liquid Nitrogen	-320	-195.6
Liquid Helium	-452	-268.9
Standard Temperature Points		
Ice Point	32	0
Boiling Point H_2O	212	100
Triple Point H_2O		0.01

6
ORDERING GUIDE

6.1 SCOPE

The following ordering guide defines the DIGI-CAL II range and power source as well as available options and accessories.

For additional information, consult the nearest address shown on the rear outside cover.

6.2 PRODUCT ORDERING GUIDE

AN6520 Digital THERMOCOUPLE INSTRUMENT CALIBRATOR

PRODUCT		ORDERING GUIDE
AN6520 □ □		**Basic Unit**
Enter		
4A		4 Range, mV ANSI J,K,T
8A		8 Range, mV ANSI J,K,T, E,R,S and C
Enter		
110		110VAC Power (U.S. Line Cord)
220		220VAC Power (European Cord)

AN6520 Options and Accessories

PRODUCT	ORDERING GUIDE
	Options
AN6520 OPT-A-□-□	**Adaptor Plug**
J,E,T,K,R,S	T/C Type
Enter	
S	Standard
M	Miniature
AN6520 OPT-C-□	**Instrument Service Cable,** 6 ft, flexible T/C wire AWG20
J,E,T,K,R,S	Teflon insulated with #6 terminals both ends; color-coded
	Accessories
Bulletin No. 16-400027	Instruction Manual

Note:
Types R and S Adapter plugs and service cables are fabricated of copper vs. alloy #11.

ANALOGIC

Solutions...not Slogans

LIMITED WARRANTY

Analogic Corporation warrants that the goods sold hereunder will conform to written specifications, drawings and other descriptions, including any modifications thereof by Analogic, for a period of twelve months from date of shipment. Analogic warrants the goods sold hereunder against faulty workmanship and defective materials. If any goods manufactured by Analogic fail to conform to these warranties, Analogic will as its sole and exclusive liability hereunder repair or replace such goods if they are returned within the following warranty period for specific instruments or systems:

These warranties are made upon the express condition that:

i) Analogic is given prompt written notice upon discovery by Buyer of such nonconformity, with a detailed explanation of the alleged deficiencies;

ii) Such goods are returned to Analogic at the expense of Buyer; and

iii) Examination of such goods by Analogic discloses that the nonconformity actually exists and was not caused by accident, misuse, neglect, alteration; improper installation, improper repair or improper testing.

iv) The goods have not been altered, modified or changed in any manner by anyone other than Analogic.

v) Repairs to the goods have not been made by anyone other than Analogic or at an Analogic authorized service facility.

Analogic will have a reasonable time to repair or replace such goods. Analogic will not in any event be liable for incidental or consequential damages. These warranties may be modified in the case of particular goods by warranties set forth on warranty certificates enclosed with the goods at the time of packaging.

THESE WARRANTIES EXCLUDE ALL OTHER EXPRESS OR IMPLIED WARRANTIES, ORAL OR WRITTEN, INCLUDING WITHOUT LIMITATION WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NO TERMS, CONDITIONS, UNDERSTANDINGS OR AGREEMENTS PURPORTING TO MODIFY THE TERMS OF THOSE WARRANTIES SHALL HAVE ANY LEGAL EFFECT UNLESS MADE IN WRITING AND SIGNED BY AN AUTHORIZED OFFICER OF ANALOGIC.

ANALOGIC®

ANALOGIC CORPORATION • Audubon Road • Wakefield, Massachusetts 01880
Tel. (617) 246-0300 • TWX (710) 348-0425 • Telex 94-9307
ANALOGIC INTERNATIONAL • Audubon Road • Wakefield, Massachusetts 01880
Tel. (617) 246-0300 • TWX (710) 348-0425 • Telex 94-9307
ANALOGIC AG • Kanalstrasse 15 • Postfach CH-8152 • Glattbrugg, Switzerland
Tel. (41) 1-810-0666 • Telex 845-59699
ANALOGIC GmbH • Daimlerring 2 • 6200 Wiesbaden — Nordenstadt • Germany
Tel. (49) 6122-4071/74 • Telex 841-4182587
ANALOGIC LIMITED • 68 High Street • Weybridge, Surrey, KT13 8BN, England
Tel. (44) 932-41251 • Telex 851-928030
ANALOGIC REGIONAL OFFICES
Cincinnati, Ohio • Tel. (606) 371-0064 • San Jose, California • Tel. (408) 247-6401
Garland, Texas • Tel. (214) 681-0483 • Houston, Texas • Tel. (713) 777-6360

Bulletin No. 16-400027 Rev 0 **Printed in U.S.A.** **Copyright 1980 ANALOGIC Corporation**